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Polymer-Silicate Admixture for C-S-H Seeding, Air Entraining, and Internal Curing of Cementitious Mixtures

Multifunctional powder seeds C-S-H, entrains air, and self-cures cement safely and efficiently.

Researchers at Purdue University have developed a multifunctional powdered polymer-silicate admixture that produces stronger and longer-lasting cement. Silica additives (silica fume, nanosilica) and calcium-silicate-hydrates (C-S-H) seeding agents are widely popular in the cement industry to help create high-strength 'glue' within cement that binds together concrete aggregates. However, the silica-based particles can produce significant inhalation hazards when incorporated into cement.

This technology helps concrete contractors create concrete with greater strength and service life by reducing concrete compaction and shrinkage during placement while encouraging and controlling the growth of strengthening phases (C-S-H seeding). Instead of traditional single-purpose silica-based particles, this innovative technology uses pH responsive organic silicate groups that are bound within a polymer particle. The resulting powdered admixture acts as a C-S-H seeding agent that can nucleate and grow concrete strengthening phases during early cement hydration. Moreover, at later time scales, the admixture acts as both an internal curing agent and air entraining agent. The admixture is produced as a dry powder that is easily incorporated into cast and printed cementitious systems.

Technology Validation:

A rheological analysis and swelling measurements were conducted to provide evidence for the successful incorporation of pH responsive organic silicate groups within the admixture particle. Rheometry data showed a greater storage modulus than loss modulus, indicating the transition from a liquid solution to a solid gel-like material with the addition of silicate groups that function as crosslinks with the polymer particle. Swelling data showed that absorption capacity was reduced for admixture particles that contained

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greater amounts of the organic silicate groups.

Electron microscopy of the cement paste containing the powdered admixture showed void spaces that are expected to entrain air. Microscopy also provided evidence of microstructure refinement in and around the location of the admixture particles, including the formation of a mixture of hydrated products within the void spaces (C-S-H, calcium hydroxide, etc.). Additionally, the chemical composition of the powdered admixture can be adjusted to allow the particle to dissolve during cement curing.

The internal curing performance of the powdered admixture is being evaluated by swelling and shrinkage studies. Swelling studies of the admixture particles immersed in high-pH fluid verifies the particle's ability to absorb and release fluid as well as its dissolution behavior. Separate studies of the drying and autogenous shrinkage of mortars containing the admixture particles are in progress.

Advantages:

-Combined properties of seeding, air entraining, and internal curing

-Enhanced safety profile

-Produces high-strength and longer lasting cement, helping to reduce carbon emissions produced by the cement industry

Applications:

-Concrete admixture manufacturing

-Concrete production

-Concrete additive manufacturing (concrete 3D printing)

TRL: 3

Intellectual Property:

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Utility Patent, 2025-02-21, United States

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